Canada

MOSST
Background Paper

18

THE REQUIREMENTS FOR ENGINEERING GRADUATES TO 1985

Ministry of State
Science and Technology Canada

Ministère d'État
Sciences et Technologie Canada

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THE REQUIREMENTS FOR ENGINEERING GRADUATES TO 1985

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Cat. No. ST41-3/1981-18E
ISBN 0-662-11840-5

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SUMMARY

This report reviews the trends in enrolments, degrees awarded and requirements for engineers over the 1970s, and then considers a number of factors bearing on the future requirements and supply to 1985. The study is based on the MOSST highly qualified manpower model and a number of recent government reports and industry statements.

In the 1970s, engineers had little difficulty in finding employment in a wide range of occupations, and employers were eager to hire engineering graduates, not only as engineers but also in related occupations. But there was a relatively slow growth in the number of student places offered by the Canadian university system, and the labour market was balanced by sizeable immigration.

Unless appropriate action is taken, and given certain assumptions, the projections indicate that the requirements for engineering graduates will exceed domestic supply. The largest shortfall, relatively speaking, will be at the graduate level, where the domestic market is expected to supply only about 60 percent of the graduates required. A number of engineering specialties are expected to be in particularly high demand over the 1980s. These include: engineering faculty; research personnel; chemical process, mechanical sales, plant instrumentation and structural engineers; aeronautics and electronics engineers, mining engineers and various types of engineers for the mega projects.

In the 1980s, the university system will have to become more flexible to be able to meet the needs and preferences of students and the labour market. At the same time, universities should continue their longstanding efforts to ensure that the engineering academic curricula are fully consistent with industry needs.

Industry, as well, can take steps to counteract the expected shortages through improving the operation of the labour market such as innovative staffing practices and more investment in existing human resources.

Increasing the level of immigration of highly qualified manpower on a selective basis can help to satisfy some of the labour market needs. In the past, immigration has been an important balancing element. However, other countries are experiencing shortages in the same skills that are in high demand in Canada, and it will become increasingly difficult to rely on immigration as a ready solution to the skill shortages.

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Recent federal initiatives have begun to increase the supply of research manpower. The Natural Sciences and Engineering Research Council has instituted a program of undergraduate research bursaries designed to attract students into graduate studies. The New Technology Employment Program developed by the Canadian Employment and Immigration Commission and the National Research Council has the objective of stimulating R&D employment in industry.

Two recent federal task forces, Canada Employment and Immigration Commission Task Force on labour market development and the Parliamentary Committee on employment opportunities for the 80s have made recommendations which could also be helpful in the engineering situation. For example, the task force on labour market development has cited the need for special thrust funding to facilitate expansion of disciplines such as engineering science.

INTRODUCTION

This study provides a discussion of the trends in enrolments, degrees awarded and requirements for engineering graduates over the 1970s. The report also considers a number of factors bearing on future requirements and supply in the 1980s and includes conditional projections of the requirements for engineering graduates to 1985.

The information contained in the report is derived from the MOSST HQM data base and projection model. Appendix C of this report provides an overview of its content and structure. Before presenting the statistical results a number of factors should be highlighted:

- historical and projected estimates are based on data provided by Statistics Canada, Employment and Immigration Commission and other government departments, and consultations with the Canadian Engineering Manpower Council (CEMC). In particular, the CEMC provided welcome advice and critical comment on the methodology and data associated with these estimates (see Appendix B for a review of data sources);

- the results for engineers take account of the latest COFOR occupation projection by the Employment and Immigration Commission. The COFOR projections include up-to-date calculations for industry growth, regional occupational trends and investments in major energy, transportation and defence projects (see Appendix Table A-1 for the COFOR employment projections by industry group);

- the estimates do not reflect short-term labour market conditions. They are however, sensitive to the cyclical swings inherent in the projection of industrial employment growth used in the HQM projections;

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- there are regional trends in requirements that differ from the aggregate national picture but these are not contained in the model;

- the estimates do not purport to measure the demand for university education. Rather, they reflect the demand for university graduates in the economy, and this is only one of several elements contributing to the demand for a university education;

- little significance should be placed on the seemingly precise nature of the numbers presented in the report. Rather, it is the general trends and relative magnitudes of the estimates that are of interest; and

- the projected estimates take into account the implications for research manpower arising from the governments GERD target. The implications for R&D manpower arising from an increase in the GERD target are discussed in "Research Manpower Requirements Arising from Accelerated Expenditures on R&D", MOSST Background Paper No. 17.

REQUIREMENTS, TRENDS IN ENROLMENTS AND DEGREES AWARDED OVER THE 1970s

Requirements

Over the period 1971 to 1978 the estimated number of persons employed in engineering occupations rose from 46,000 to almost 70,000 or at about 3,200 per year. In order to obtain the total requirements, attrition must be taken into account. When replacement growth due to death, retirement and emigration is included, requirements for persons to be employed in engineering occupations grew at about 4,400 per year (see Table 1).

Of the 4,400 persons required each year, for engineering occupations, about 80% were estimated to have been graduates in engineering. The remaining 20% come from other, usually related, fields of study. Thus, the number of engineering graduates required for engineering occupations is estimated at about 3,700 per year, from 1972 to 1978. However, this is only part of the requirements for engineering graduates.

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Table 1

ESTIMATE OF THE STOCK OF PERSONS IN THE ENGINEERING OCCUPATIONS

(1972 to 1978)

NUMBER OF PERSONS

	TOTAL ENGINEERS	ANNUAL INCREASE	REPLACEMENT DEMAND	NEW ENTRANTS REQUIRED
1971	46,100	--	--	--
1972	49,900	3,800	1,100	4,900
1973	53,900	4,000	1,100	5,100
1974	57,600	3,700	1,100	4,800
1975	61,100	3,500	1,150	4,650
1976	64,100	3,000	1,150	4,150
1977	66,600	2,500	1,200	3,700
1978	69,100	2,500	1,250	3,750

Source: MOSST, HQM Model and Data Base.

Traditionally, engineering graduates have also been required for jobs in occupations other than engineering. It is estimated that the requirements for engineering graduates for non-engineering occupations (including university teaching, administration, etc.) amounted to about 2,700 per year. (See Table 2.)

In total, about 6,400 graduates in engineering were required each year from 1972 to 1978, about 60% for engineering jobs and 40% for other HQM jobs. As shown in Table 2, most of the engineering graduates were required with qualifications at the first degree level. About 85% were required with undergraduate degrees and 15% with graduate degrees.

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Table 2

REQUIREMENTS FOR ENGINEERING GRADUATES

(1972 to 1978)

	REQUIREMENTS (ALL DEGREE LEVELS)			REQUIREMENTS BY DEGREE LEVEL	
	ENGINEERING GRADUATES FOR ENG. OCCS.	ENGINEERING GRADUATES OTHER OCCS.	TOTAL ENGINEERING GRADUATES	FIRST DEGREE	GRADUATE DEGREE
1972	4,070	2,610	6,680	5,590	1,090
1973	4,230	2,830	7,060	5,920	1,140
1974	3,990	2,900	6,890	5,770	1,120
1975	3,860	2,530	6,390	5,360	1,030
1976	3,500	2,610	6,110	5,120	990
1977	3,070	2,700	5,770	4,870	900
1978	3,110	2,840	5,950	5,020	930

Source: MOSST, HQM Model and Data Base.

Recent Trends in Enrolments and Degrees Awarded[1]

Full-time enrolments and degrees awarded in engineering are shown in Table 3 for the period 1972 to 1978. Undergraduate enrolments in engineering began to rise steadily from 19,800 in 1972-73 to 29,000 in 1978-79. Degrees awarded decreased from 1972 to 1975 but then started to rise over the next three years, reflecting the growth in full-time and part-time enrolment which began in the early 1970s.

At the graduate level, both full-time enrolments and degrees awarded remained relatively constant over the period 1972 to 1978. However, the trends differed at the master and PhD levels, as shown in Table 4. At the masters level, full-time enrolments and degrees awarded increased slightly over the

[1] More details are provided in Appendix A, Tables A-2 to A-5.

Table 3

FULL-TIME ENROLMENTS AND DEGREES AWARDED IN ENGINEERING[1]

1972-73 to 1978-79

	UNDERGRADUATE		GRADUATE		TOTAL	
	ENROLMENTS	DEGREES AWARDED	ENROLMENTS	DEGREES AWARDED	ENROLMENTS	DEGREES AWARDED
1972-73	19,790	4,222	2,919	1,221	22,709	5,443
1973-74	19,965	4,205	2,766	1,211	22,731	5,416
1974-75	21,631	4,175	2,914	1,164	24,545	5,339
1975-76	24,155	3,894	3,164	1,023	27,319	4,917
1976-77	26,414	4,134	2,958	1,118	29,372	5,252
1977-78	28,148	4,513	2,921	1,236	31,069	5,749
1978-79	29,325	5,105	2,744	1,234	32,069	6,339

Source: Statistics Canada, "Universities: Enrolments and Degrees", Cat. No. 81-204, 1972/73 to 1978, Annuals.

[1] Excludes Forestry and Architecture.

1970s. In contrast, PhD enrolments and degrees awarded decreased over the 1970s. Full-time enrolments decreased from 1140 in 1972 to 840 in 1978 and degrees awarded decreased from 260 in in 1972 to 220 in 1978.

Part-time graduate enrolments are shown in Table 5 for the period 1972 to 1977. The relatively faster growth in part-time studies is of interest. In 1973, 15 percent of engineering students were part-time (in full-time equivalents, see footnote, Table 5). By 1978 this ratio had increased to 22 percent.

A significant feature of recent enrolment trends in engineering has been the relatively faster growth in foreign (visa) students, particularly at the graduate level. As shown in Table 6, the percentage of foreign student enrolments grew from 7 percent to

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11 percent at the undergraduate level and from 18 percent to 34 percent at the graduate level over the period of 1972 to 1978. These are students who return to their country after receiving their degrees at Canadian universities, and are not available for employment in the Canadian labour market.

Table 4

GRADUATE FULL-TIME ENROLMENTS AND DEGREES AWARDED

ENGINEERING[1]

(1972 to 1978)

	ENROLMENTS			DEGREES AWARDED		
	Masters	PhD	Total	Masters	PhD	Total
1972-73	1,779	1,140	2,919	963	258	1,221
1973-74	1,749	1,017	2,766	921	290	1,211
1974-75	1,956	958	2,914	869	295	1,164
1975-76	2,226	938	3,164	815	208	1,023
1976-77	2,003	955	2,958	938	180	1,118
1977-78	1,998	923	2,921	1,039	197	1,236
1978-79	1,903	841	2,744	1,016	218	1,234

Source: Statistics Canada, "Universities: Enrolments and Degrees", Cat. No. 81-204, 1972/73 to 1978, Annuals.

[1] Excludes forestry and architecture.

The capacity of the universities to supply engineering graduates decreased slightly to 1975 and then showed a marked increase to 1979. Not all new graduates are available to the labour market. Table 7 shows the steps in adjustments from degrees awarded to domestic supply. Deductions are made from the total number of degrees awarded for part-time students (who are assumed to have a job), foreign students returning home, and graduates who continue their education. Taking into consideration these factors, total domestic supply decreased slightly to 1975 and then increased to 1979.

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Table 5

PART-TIME GRADUATE ENROLMENT IN ENGINEERING
AT CANADIAN UNIVERSITIES

(1972-73 to 1978-79)

	Masters	PhD	Total (FTE)[1]	Part-Time (FTE) As % Of Total (FTE)
1972-73	1,073	252	530	15.4
1973-74	1,220	276	598	17.8
1974-75	1,439	283	689	19.1
1975-76	1,563	271	734	18.8
1976-77	1,793	267	824	21.8
1977-78	1,701	273	790	21.3
1978-79	1,621	257	751	21.5

Source: Statistics Canada, "Universities: Enrolments and Degrees", Cat. No. 81-204, 1972/73 to 1978, Annuals.

[1] 2.5 Part-Time Equals 1 Full-Time.

SUMMARY OF TRENDS OVER THE 1970s

Over the period 1972 to 1978 the number of engineering graduates required for all HQM jobs averaged about 6,400 per year. The estimated production of engineering graduates from domestic sources and available for jobs averaged about 3,900 per year, with the balance made up of Canadians receiving their degrees from abroad and returning home, and by immigration.

Graduates in engineering have found no difficulty in moving into HQM jobs which are not necessarily related to the engineering profession. For example, it was previously noted that about 40% of all engineering graduates found HQM jobs not directly related to engineering. Associated with this has been the eagerness of employers to hire engineering graduates, not only as engineers but also in related occupations.

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Table 6

FOREIGN STUDENT ENROLMENT (FULL-TIME) - ENGINEERING[1]

1973-74 to 1978-79

	STUDENT VISAS		STUDENT VISAS AS A PERCENTAGE OF FULL-TIME ENROLMENT	
	UNDERGRADUATE	GRADUATE	UNDERGRADUATE	GRADUATE
1972-73	1,337	517	6.8	17.7
1973-74	1,262	458	6.3	16.6
1974-75	1,280	595	5.9	20.4
1975-76	2,153	753	8.9	23.8
1976-77	2,341	735	8.9	24.9
1977-78	3,036	920	10.8	31.5
1978-79	3,266	923	11.1	33.6

Source: Statistics Canada, "Universities: Enrolment and Degrees", Cat. No. 81-204, Annual and Special Tabulations on Foreign Student Enrolment by Education Division, Statistics Canada.

[1] Excludes Forestry and architecture.

A relatively slow growth in the number of student places offered by the Canadian university system is due, in part, to enrolment controls. For example, engineering programs have restricted enrolments in Alberta, Saskatchewan, Manitoba, Toronto, Queens and Montreal. In most universities this is accomplished through a quota system and a floating grade requirement.

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Table 7

ANALYSIS OF SUPPLY OF ENGINEERING GRADUATES

(ALL DEGREE LEVELS)

		1972	1973	1974	1975	1976	1977	1978
	Degrees Awarded	5,443	5,416	5,339	4,917	5,252	5,749	6,339
	Part-Time Graduates	136	161	178	168	173	215	233
LESS:	Foreign Graduates Returning Home	641	678	684	640	720	785	845
	Graduates Continuing Education	937	853	788	727	789	805	860
EQUALS:	Available Domestic Supply	3,729	3,724	3,689	3,382	3,570	3,944	4,401

Source: MOSST, "Recent Trends in Degrees Awarded and Enrolment at Canadian Universities", Background Paper No. 14, Appendix B.

A factor in the balanced labour market has been the reliance by the country on foreign trained manpower. In the past, foreign trained graduates have been readily available as the need arose. For example, the number of immigrants with an engineering degree averaged about 2,000 per year from 1972 to 1975 and fell to about 1,500 per year from 1976 to 1979.

TRENDS TO THE MID 1980s

As Canada enters the 1980s, it is evident from a number of studies and observations that requirements for engineering graduates will remain high, and may well exceed current levels of domestic production. The following discussion of future requirements and supply considers the MOSST projections and also several other factors such as regional shortages of supply and the high levels of demand in specialized fields.

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AGGREGATE TRENDS IN REQUIREMENTS AND AVAILABLE SUPPLY 1979-1985

The number of persons employed in engineering occupations is expected to rise from 72,000 to 92,000 (Table 8) or by 20,000 persons over the period 1979 to 1985. Total replacements due to attrition of the stock are estimated at 9,000 over this same period, for a combined total demand of 29,000.

Of the 29,000 persons required to fill engineering jobs, about 80% or 24,000 are expected to possess degrees in engineering. A further 21,400 engineering graduates are expected to be required for HQM jobs other than engineering. These jobs would include such functions as administration, teaching, and research and development. Thus, in total, it is estimated that about 45,000 engineering graduates will be required over the period 1979 to 1985. About one-quarter will require post-graduate degrees and the other three-quarters will need at least a first degree (see Table 9).

Table 8

ESTIMATES OF THE STOCK OF PERSONS IN THE ENGINEERING OCCUPATIONS

(1979 to 1985)

NUMBER OF PERSONS

	TOTAL ENGINEERS	ANNUAL INCREASE	REPLACEMENT DEMAND	NEW ENTRANTS REQUIRED
1979	71,900			
		3,200	1,450	4,650
1980	75,100			
		3,200	1,450	4,650
1981	78,300			
		3,200	1,450	4,650
1982	81,500			
		3,400	1,550	4,950
1983	84,900			
		3,400	1,550	4,950
1984	88,300			
		3,600	1,650	5,250
1985	91,900			

Source: MOSST, HQM Model and Data Base.

Table 9

REQUIREMENTS FOR ENGINEERING GRADUATES

(1979 to 1985)

	REQUIREMENTS (ALL DEGREE LEVELS)			REQUIREMENTS BY DEGREE LEVEL	
	ENGINEERING GRADUATES FOR ENG. OCCS.	ENGINEERING GRADUATES OTHER OCCS.	TOTAL ENGINEERING GRADUATES	FIRST DEGREE	GRADUATE DEGREE (A)
1979	3,850	3,200	7,050	5,230	1,820
1980	3,850	3,350	7,200	5,360	1,840
1981	3,900	3,550	7,450	5,570	1,880
1982	4,000	3,650	7,650	5,740	1,910
1983	4,100	3,750	7,850	5,910	1,940
1984	4,300	3,900	8,200	6,210	1,990
1985					

Source: MOSST, HQM Model and Data Base.

(A) These estimates take account of the implications for research manpower arising from the government's GERD target. The implications for the increased R & D manpower are discussed in "Research Manpower Requirements Arising from Accelerated Expenditures on R & D", MOSST Background Paper No. 17.

The projections take into consideration a number of factors. These include:

- total employment by industry projections based on the 1981 Candide projections used by the CEIC in the COFOR model (see Appendix A, Table A-1);

- technological change and inter-industry shift effects;

- attrition calculations for replacement demand by occupation based on death and retirement rates and emigration assumptions; and

- the increased requirements for R&D manpower arising from the Government's GERD target (see "Research Manpower Requirements Arising from Accelerated Expenditures on R&D", MOSST Background Paper No. 17).

The current (1978-79) number of engineering degrees awarded at Canadian universities is about 6,300 (of which some 5,100 are at the first degree level and 1,200 at the post-graduate level). Assuming no significant declines in enrolments, this implies a total number of about 38,000 degrees would be awarded between 1979 to 1985. However, not all of these graduates would be available to the domestic labour market. Some of the students will graduate from part-time studies and will already be employed; some will be visa students who will return to their home countries and some graduates will continue their education on a full-time basis. When these factors are taken into consideration, and including an estimate of Canadian students returning home, it is estimated that the net available supply of engineering graduates to the Canadian labour market will number about 32,600 to 1985. This estimate of future supply excludes immigration of engineers which over the last 4 years has averaged about 1,500.

Table 10

ESTIMATED REQUIREMENTS AND AVAILABLE SUPPLY
FOR ENGINEERING GRADUATES

1979-1985

NUMBER OF GRADUATES

	FIRST DEGREE	GRADUATE	TOTAL
HQM Requirements	34,000	11,000	45,000
Supply (excl. imm.)	26,300	6,300	32,600
Imbalance	-7,700	-4,700	-12,400

Source: MOSST, HQM Model and Data Base, 1980.

Table 10 summarizes the projected requirements and supply situation for engineering graduates to 1985. In total, the projections indicate that requirements for engineering graduates will exceed domestic supply by some 12,400. In relative terms, the largest shortfall is at the graduate level, where the domestic market is expected to supply only about 60 percent, or 6,300 out of the 11,000 graduates required to 1985.

REQUIREMENTS FOR SPECIFIC ENGINEERING SPECIALTIES

The previous section was concerned with the overall requirements and available supply situation to the mid 1980s. This section provides a brief discussion of the several engineering specialties which are expected to be in high demand over the 1980s. The sources of the information are government and industry studies.

University Faculty - In its brief to the Task Force on "Employment Opportunities for the 1980s", the Canadian Engineering Manpower Council made specific note of the present and expected shortages of university engineering faculty. The Council has pointed out that due to the excellent employment markets and relative decline in university pay scales, there are presently over 200 faculty vacancies in engineering across Canada. The situation threatens to worsen over the 1980s, unless measures are taken to encourage graduate study and teaching in engineering.

Research Personnel Requirements - Professional research personnel requirements arising from the 1.5% R&D target have been estimated by MOSST under several sets of assumptions, indicating a possible shortfall by 1985 of about 4,000 persons with research degrees, with approximately three-quarters of this shortfall in the applied sciences and engineering. (See "Research Manpower Requirements Arising from Accelerated Expenditures on R&D", MOSST Background Paper No. 17.)

Chemical Process, Mechanical Sales, Plant Instrumentation and Structural Engineers - The Technical Service Council has reported on the shortages of qualified engineering and technical personnel for a number of years now. In recent quarterly surveys of jobs, the Council found a large number of vacancies for engineers, specifically chemical process, mechanical sales, plant instrumentation and structural engineers. The Council indicates that engineers will be among those having the best job opportunities in the 1980s, not only for new graduates but also for the experienced engineering professionals.

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Aeronautical Engineers - Shortages of aerospace engineers have been reported, especially for Ontario and Quebec, and this situation is expected to worsen over the 1980s. According to studies carried out by the aerospace industry and the CEIC, total employment growth will be in the 15% to 20% range for at least the next five years. Canadian universities are presently having problems supplying the market with engineers trained in the aeronautics field. This projected growth rate implies a greater demand to the mid 1980s.[2]

Electronic Engineers - The electronics and electrical industry is another high growth sector which will place heavy demands for specialized engineering manpower. It has been estimated that this industry could create at least 100,000 new job openings (all occupations) and $60 billion in new sales by the end of the decade. According to industry reports, Canada is presently experiencing shortages of manpower in the areas of electrical and electronic engineering and the expected world wide growth in the sector will place even higher demands on the availability of engineering graduates for these specialized fields.

Engineers Required For Mega Projects - The large energy projects in Eastern and Western Canada have also led industry officials to warn of impending engineering shortages. A recent study of the engineering requirements for the identified mega projects, which takes account of design and pre-construction requirements as well as those involved in construction and operations phases, concludes that the requirements are likely to increase dramatically in the 1980s.[3] With development of such projects as Alsands, Cold Lake and the Alaska Highway Pipeline, demand for engineers will be highest for such specialties as:

- chemical, including process engineers;
- civil engineers;
- electrical engineers;
- industrial engineers;
- mechanical engineers; and
- petroleum engineers.

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[2]See for example, the Sector Task Force on the Canadian Aerospace Industry Report prepared for the House of Commons, Special Committee on Employment Opportunities for the 1980s, and "Occupational Requirements to 19 ". Canadian Occupational Forecasting Program (COFOR), Department of Employment and Immigration, 1981.

[3]See, "Engineering Manpower Requirements 1980-2000 For Major Energy-Related Projects in Canada", Report prepared by Govier Consulting Services Ltd. for the Canadian Council of Professional Engineers, 1980.

The Canadian Council of Professional Engineers, the Technical Service Council and the Canadian Employment and Immigration Commission have all reported expected shortages of engineers for the Western mega energy projects. According to the Canadian Petroleum Association, "if all the engineering requirements for one project, Cold Lake, were done in Canada, that project alone could absorb 60 percent of Canada's engineering capacity".

Mining Engineers - It has been pointed out, by industry officials, that the mining industry also expects to make new capital investments of at least $42 billion before 1990. In British Columbia, for example, 27 new coal mining projects are projected over the next five years. These projects are expected to give rise to shortages of engineers and skilled manpower in the mining field.

IMPLICATIONS FOR POLICY

This report indicates that unless suitable action is taken, shortages of engineers can be expected. Particular problem areas are specialities such as university teaching, research and development, electronics and energy related engineering. In order to deal with these shortages, appropriate responses will be required from the universities, industry and government.

Responsive University System - The capacity of the universities is barely sufficient to meet the existing requirements, not to mention the requirements over the 1980s. The universities will be affected by a number of influences which will further reduce their ability to respond to increased student demand. These include: a gradual decrease in the 18-24 year old population (the group most likely to attend university), and a post-secondary education system which will become increasingly constrained in financial terms if provincial priorities shift and should provincial funding formulas based on enrolment reduce university operating flexibility. Although student demand for entry to the engineering and applied sciences programs is high and will likely remain high through the decade, the overall constraints imply that special efforts will be required by the universities to meet these increased demands.

Regarding this issue, the Canadian Engineering Manpower Council, in its brief to the Task Force on Employment Opportunities for the 1980s, made the following comment:

> Adequate funding of our universities and colleges to allow replacement of equipment, expansion of facilities, and fair salaries for faculty and support staff will pay great dividends in our

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> future ecomonic development. The graduates of those post-secondary institutions will be at the frontiers of technological and economic progress in Canada. If our educational system is allowed to deteriorate, if pure and applied research dwindles, if morale and quality of teaching drop, we can forget about Canada's long-term future.

One of the first imperatives, therefore, is that the university system should become more responsive to the needs and preferences of students, which are to an increasing extent affected by the labour market. One of the more intractable problems in this effort might be the realignment of university teaching staff with changes in the emerging student demand. It is important also that the engineering profession continue its longstanding efforts to ensure that the engineering academic curricula are fully consistent with industry needs.

The federal government transfers cash and tax points to the provinces for post-secondary education. These transfers, under the present (1977) arrangements, are very large in value and approach 60 percent of the cost of post-secondary education. In view of the growth and size of these transfers and the concerns about the health of the university system and its ability to meet the needs of the 80s, the provinces and the federal government will negotiate new fiscal arrangements in the coming years.

Industry Staffing Practices - Industry, as well, can take steps to counteract the expected shortages. More could be done in improving the operation of the labour market, such as innovative staffing practices and more investment in existing human resources. In this respect, specific suggestions outlined by the Technical Service Council deserve consideration:

- rehiring retired or part-time staff specialists;
- making special efforts to retain staff by setting up more flexible in-house systems;
- using more creative recruiting techniques;
- hiring more trainees;
- reviewing the utilization of engineers, using lesser trained employees where possible; and
- recognizing that professional staff can be adaptable and retraining them for new tasks.

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Selected Increases and Strategic Use of Immigration - Increasing the level of immigration of HQM on a selective basis is an option for helping to satisfy the needs of the labour market. The strategic use of immigration (permanent and temporary) of key engineering expertise should result in the transfer of needed skills and know-how to Canadians, thereby building domestic engineering capacity. An example of this is the current practice of permitting key engineering manpower to work in Canada on a temporary basis on the condition that they assist in training Canadians.

Although immigration has been an important balancing element in the past, as discussed previously, it is becoming apparent that in the 1980s Canada will have to become much more competitive in its efforts to attract engineers to Canada. International shortages are now beginning to materialize and the situation is expected to worsen.[4]

Improved Labour Market Information - Canada is rich in human resources. Its labour force is well-educated, youthful, and enterprising. An excellent post-secondary education system is in place. A key problem, however, is matching people and jobs, and planning for the training of people for the jobs that will be created in the future. A Canada Employment and Immigration Commission task force report (Task Force on Labour Market Development), released in June 1981, calls for improved labour market information, including the development of regional manpower plans in cooperation with industry, targetting of training funds to correct skill imbalances, and an expansion in the role of the Canada Employment Centres to include computerized job banks and a tie-in with available training programs and counselling services. These proposals, and other changes that may be ultimately implemented, have the objective of improving the utilization and mobility of Canada's human resources.

The Canadian Engineering Manpower Council is in the process of establishing an engineering manpower inventory which, when completed, will clearly improve our knowledge of the supply of engineers. This information will be useful in planning Canada's engineering manpower needs.

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[4] See for example, Engineering Our Future, (Finiston Report), Report of the Committee of Inquiry Into The Engineering Profession, London, HMSO, January 1980, Pages 75 and 76; Eastwood, Gerry, Skilled Labour Shortages in the United Kingdom, British-North American Committee, 1976; National Science Foundation and the Department of Education, Science and Engineering Education for the 1980s and Beyond, October 1980; and Canadian Engineering Manpower Council, Engineering Manpower News, No. 24, August 1980.

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R&D Manpower - Researchers with graduate training in engineering and applied sciences are required for work in such diverse fields as microelectronics, biotechnology, computer science, agriculture, forestry and geosciences. In many of these fields there are shortages of qualified faculty as well as shortages of graduates. The main problem is that the employment market for bachelor-level graduates in these fields is excellent and salaries are high, thereby attracting potential students away from graduate studies and into the general labour market. Moreover, in their current weakened financial position, universities are having difficulty in retaining qualified faculty and filling existing vacancies in the face of strong private sector demand. Shortages of faculty, in turn, lead to restricted graduate training capacity, and this further reduces the potential supply of research-trained manpower.

In the face of these developments, some industries with particularly pressing requirements for R&D manpower (microelectronics, computer science and forestry, for example) are actively developing and participating in cooperative graduate programs with universities and funding university research chairs and research programs in fields of primary interest to the industry. This form of university-industry cooperation is beneficial to the student, the industry and the university. The student has an opportunity to develop employment and experience links with several firms, and receives pay which offsets the high personal costs of graduate education. Industry and universities each benefit from the increased contact between these two "solitudes" resulting in increased transfer of expertise and an improved mutual awareness of the problems and strengths of the other.

Government Response - The federal government has maintained a long standing involvement and concern for the national research capacity and the adequacy of the supply of highly qualified manpower.

The expected shortages and financial constraints in university financing have led to the development of federal initiatives to encourage an increased supply of research manpower. The Natural Sciences and Engineering Research Council (NSERC), in its five-year plan, has identified scientific manpower as a key priority in view of the R&D target and the problems facing the university system. In addition, NSERC is concerned about the extent to which the university research equipment base has deteriorated during the 1970s. The plan also notes that engineering research grants need special attention; the evaluation criteria for engineering research proposals should place more emphasis on potential patents, rather than potential academic papers, for example.

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NSERC has established two new programs to help alleviate the emerging manpower shortages. These are the Undergraduate Summer Research bursaries and a new Research Fellowship program. The research bursaries are designed to attract undergraduate students into graduate studies through summer work experience on research projects. The research fellowships provide for full-time research positions tenable at universities or in industry for up to five years. These fellowships provide competitive research careers for young researchers and help maintain the capacity of the system. The stipends paid by NSERC for graduate scholarships were increased sharply in 1980 and 1981 in an effort to help close the gap between starting salaries of bachelor level graduates and the costs of graduate study. Moreover, NSERC has embarked on a major equipment refurbishing program this year, and has strengthened its support of free research and strategic research in areas of national concern.

Other government departments and agencies have also instituted programs to help alleviate potential shortages. The CEIC is currently entering into manpower planning agreements with key industrial sectors, such as the aeronautics and electronics industries. In total, Canada spends about $700 million per year on job training programs and these agreements will allow better targetting of these funds over the 1980s. The CEIC with NRC are operating a technology employment program called the "New Technology Employment Program" (NTEP) with the objective of stimulating R&D employment in industry. The department of Industry, Trade and Commerce recently announced a Microelectronics Support Program at six Canadian universities. Although this program is not intended to train manpower directly, it will serve to transfer technology and reduce the net balance of manpower skills needed by industry to achieve the same purpose.

Two recent federal task forces, the CEIC Task Force on labour market development and the Parliamentary Committee on employment opportunities, have studied the issue of the federal role in manpower supply. These Task Forces have outlined a number of recommendations which also could be helpful in the engineering situation. For example, the CEIC Task Force on labour market development called for changes in post-secondary funding including: expanded support for cooperative education programs; thrust funding to facilitate expansion of disciplines such as engineering science; and a system of matching grants to employers for those who sponsor needed specialized training in colleges and universities.

APPENDIX A

SELECTED TABLES

TABLE A-1

TOTAL EMPLOYMENT BY INDUSTRY (1971, 1979 AND 1985)

	THOUSANDS OF PERSONS			COMPOUND ANNUAL GROWTH RATE	
	1971	1979	1985	1971-1979	1979-1985
AGRICULTURE	490.3	485.8	467.0	-0.1	-0.7
OTHER PRIMARY	242.5	276.6	339.3	1.7	3.5
MANUFACTURING	1,772.3	2,072.4	2,235.2	2.0	1.3
CONSTRUCTION	554.0	641.2	795.6	1.8	3.7
TRANSPORTATION, COMMUNICATION & UTILITIES	691.2	894.4	1,058.8	3.3	2.9
TRADE	1,307.6	1,804.0	2,119.7	4.1	2.7
FINANCE, INSURANCE & REAL ESTATE	370.0	550.8	636.0	5.1	2.4
COMMUNITY, BUSINESS & PERSONAL SERVICES	2,107.4	2,943.7	3,573.3	4.3	3.3
PUBLIC ADMINISTRATION	567.0	702.4	803.7	2.7	2.3
TOTAL ALL INDUSTRIES	8,102.3	10,371.3	12,028.6	3.1	2.5

SOURCE: As per 1981 CANDIDE projections used by CEIC in the COFOR model, CANDIDE ECONOMETRIC MODEL, 1981.

TABLE A-2

ENGINEERING DEGREES AWARDED BY ENGINEERING SPECIALTY
TOTAL - ALL DEGREE LEVELS

	1972	1973	1974	1975	1976	1977	1978
CHEMICAL	615	613	606	507	488	554	653
CIVIL	1,113	1,106	1,090	1,100	1,229	1,424	1,544
ELECTRICAL	1,231	1,227	1,209	1,112	1,271	1,269	1,410
MECHANICAL	1,137	1,128	1,115	937	954	1,089	1,255
METALLURGICAL	141	142	140	99	116	113	120
AERONAUTICAL	20	19	18	20	21	25	27
MINING & GEOLOGICAL	313	312	308	252	217	234	256
PETROLEUM	45	84	55	11	2	6	8
INDUSTRIAL	183	183	181	133	153	173	193
AGRICULTURAL	97	96	94	86	67	69	86
OTHER ENGINEERING	548	506	523	660	734	793	787
TOTAL	5,443	5,416	5,339	4,917	5,252	5,749	6,339

SOURCE: STATISTICS CANADA, EDUCATION DIVISION, 'UNIVERSITIES: ENROLMENT AND DEGREES', CAT. NO. 81-204, AND SPECIAL TABULATIONS AT THE FIRST DEGREE LEVEL.

TABLE A-3

ENGINEERING DEGREES AWARDED BY ENGINEERING SPECIALTY
FIRST PROFESSIONAL DEGREE LEVEL

	1972	1973	1974	1975	1976	1977	1978
CHEMICAL	466	464	461	361	346	410	507
CIVIL	850	847	841	881	986	1,143	1,298
ELECTRICAL	918	915	908	899	993	959	1,111
MECHANICAL	936	931	925	800	800	897	1,068
METALLURGICAL	107	107	106	80	90	78	72
AERONAUTICAL	-	-	-	-	-	-	-
MINING & GEOLOGICAL	257	256	254	207	187	188	198
PETROLEUM	43	65	47	6	-	2	7
INDUSTRIAL	165	164	163	104	128	139	154
AGRICULTURAL	77	77	76	66	48	54	71
OTHER ENGINEERING	403	379	394	490	556	643	619
TOTAL	4,222	4,205	4,175	3,894	4,134	4,513	5,105

SOURCE: STATISTICS CANADA, EDUCATION DIVISION, 'UNIVERSITIES: ENROLMENT AND DEGREES', CAT. NO. 81-204, AND SPECIAL TABULATIONS AT THE FIRST DEGREE LEVEL.

TABLE A-4

ENGINEERING DEGREES AWARDED BY ENGINEERING SPECIALTY
MASTER'S DEGREE LEVEL

	1972	1973	1974	1975	1976	1977	1978
CHEMICAL	104	99	94	101	106	110	112
CIVIL	218	208	197	180	224	248	210
ELECTRICAL	237	226	214	158	217	252	239
MECHANICAL	163	155	147	106	129	154	151
METALLURGICAL	21	20	19	18	21	27	34
AERONAUTICAL	18	17	16	16	17	20	21
MINING & GEOLOGICAL	45	43	41	35	25	40	45
PETROLEUM	-	12	6	4	2	4	1
INDUSTRIAL	15	15	14	23	22	34	37
AGRICULTURAL	19	18	17	18	18	13	13
OTHER ENGINEERING	123	108	104	156	157	137	153
TOTAL	963	921	869	815	938	1,039	1,016

SOURCE: STATISTICS CANADA, EDUCATION DIVISION, 'UNIVERSITIES: ENROLMENT AND DEGREES', CAT. NO. 81-204, AND SPECIAL TABULATIONS AT THE FIRST DEGREE LEVEL.

TABLE A-5

ENGINEERING DEGREES AWARDED BY ENGINEERING SPECIALTY
PH.D DEGREE LEVEL

	1972	1973	1974	1975	1976	1977	1978
CHEMICAL	45	50	51	45	36	34	34
CIVIL	45	51	52	39	19	33	36
ELECTRICAL	76	86	87	55	61	58	60
MECHANICAL	38	42	43	31	25	38	36
METALLURGICAL	13	15	15	1	5	8	14
AERONAUTICAL	2	2	2	4	4	5	6
MINING & GEOLOGICAL	11	13	13	10	5	6	13
PETROLEUM	2	7	2	1	-	-	-
INDUSTRIAL	3	4	4	6	3	-	2
AGRICULTURAL	1	1	1	2	1	2	2
OTHER ENGINEERING	22	19	25	14	21	13	15
TOTAL	258	290	295	208	180	197	218

SOURCE: STATISTICS CANADA, EDUCATION DIVISION, 'UNIVERSITIES: ENROLMENT AND DEGREES', CAT. NO. 81-204, AND SPECIAL TABULATIONS AT THE FIRST DEGREE LEVEL.

APPENDIX B

RECONCILIATION OF CENSUS AND CEMC ENGINEERING STOCK DATA

APPENDIX B

Purpose

The purpose of this note is to provide a reconciliation between estimates of the number of engineers as defined by the 1971 Census, and estimates for 1971 provided by the Canadian Engineering Manpower Council (CEMC) through their membership lists. The results of this work are the culmination of numerous working group discussions between the CEMC, Employment and Immigration Commission, Statistics Canada and the Ministry of State for Science and Technology.

Background

According to the membership lists of the Canadian Council of Professional Engineers (CCPE), it was estimated that as of December 1971, there were about 64,000 professional engineers. It was also estimated that these lists included about 85 percent of all engineers. This implied that the CEMC estimate of total engineers in 1971 was 75,400. According to the 1971 Census, the number of people in engineering occupations was 76,800. On the surface, it would then appear that these two estimates were compatible. However, the CEMC figures pertained to a population of which approximately 90 percent of the members had university degrees. In the Census population between 50 and 60 percent had university degrees. It was therefore clear that the observed compatibility of the two estimates was an illusion, and that further analysis was necessary.

Analysis

The CEMC figures include not only engineering graduates employed in engineering but also engineers employed in other occupations (e.g., management, teaching, etc.). Engineering graduates employed in non-engineering jobs could not be identified by the Census. However, the Highly Qualified Manpower Post-Censal Survey (HQMPS) of 1973 provides a vehicle to obtain such estimates, since it includes field of study as well as occupational data. The HQMPS distributions applied to the Census estimates permit making an approximation to the CEMC population. Table B-1 gives, for each engineering occupation, the total Census estimate, the Census estimate of degree holders, the HQMPS

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estimate of the percentage of degree holders in each engineering occupation whose last highest degree was in an engineering field of study, and the resultant estimate of engineering graduates in the engineering occupations.

According to Table B-1, there were 5,900 engineers whose last highest degree obtained by 1971 was not in an engineering field of study. If we accept the CEMC estimate that 90 percent of all engineers had degrees, there were about 4,600 engineers without degrees. In other words, in 1971 there were approximately 10,500 people in engineering occupations who did not have a degree in engineering, in addition to the 35,500 who possessed an engineering degree, or a total of 46,000 persons in the engineering occupation. This is the base number that underlines this study.

Based on the 1973 HQMPS, the estimated number of engineering graduates (with a university degree) employed in all HQM occupations is shown in Table B-2. This table provides a total 1971 estimate of 64,000 graduates. This number, combined with the previous estimate of 10,500 in engineering occupations who did not have a degree in engineering, yields a total engineering population of 74,500. This is similar in magnitude and definition to the estimate in the CEMC membership lists.

In summary, it appears that the CEMC and Census estimates are broadly comparable only after adjustments are made for the differing definitions. It should be noted that minor differences still remain. For example, the CEMC estimate was based on December 1971, while the Census estimate pertains to June 1971. It is likely, that if the Census had been taken in December of 1971, the estimate of the number of engineers would have been higher. Nevertheless, it does seem that the two estimates are reasonably compatible.

TABLE B-1

1971 CENSUS ESTIMATES OF THE NUMBER OF ENGINEERS

OCCUPATION	OCM NO.[1]	CENSUS ESTIMATE[2]	NUMBER WITH DEGREES[2]	HQMPS % ESTIMATE OF ENG. GRADS. IN ENG. OCCUPATIONS[3]	ENG. GRADS.*
Chemical Eng.	2142	3460	2850	86.5	2465
Civil Eng.	2143	21440	13930	90.4	12586
Electrical Eng.	2144	14995	8745	89.6	7838
Mechanical Eng.	2147	12840	6250	94.8	5922
Metallurgical Eng.	2151	835	620	88.7	550
Aeronautical Eng.	2155	1530	570	87.5	499
Mining Eng.	2153	2020	1230	75.4	928
Petroleum Eng.	2154	1370	955	93.4	892
Industrial Eng.	2145	14675	3970	63.4	2517
Other Eng.	2157-59	3640	2340	59.3	1387
TOTAL		76805	41460	85.8	35584

SOURCES: [1]Statistics Canada, Occupation Classification Manual (OCM), Census of Canada, 1971 (Cat. No. 12-538).

[2]Statistics Canada, 1971 Census of Canada, (Cat. No. 94-729, Vol. III, Part 3 (Bulletin 3.3-2), June 1978.

[3]Statistics Canada, Highly Qualified Manpower Post-Censal Survey, 1973.

NOTE: *This column is the product of the two previous columns.

TABLE B-2

HQMPS ESTIMATE OF NUMBER OF ENGINEERING GRADUATES BY FIELD OF STUDY EMPLOYED IN ALL HQM OCCUPATIONS

FIELD OF STUDY	NUMBER OF GRADUATES
Chemical Eng.	7,159
Civil Eng.	16,555
Electrical Eng.	14,210
Mechanical Eng.	13,746
Metallurgical Eng.	1,425
Aeronautical Eng.	868
Mining Eng.	3,499
Petroleum Eng.	603
Industrial Eng.	1,418
Other Eng.	4,559
TOTAL	64,042

SOURCE: Statistics Canada, Highly Qualified Manpower Post-Censal Survey, 1973.

APPENDIX C

CALCULATION METHOD

APPENDIX C

A comprehensive exposition of the methodology is contained in a separate paper.[1] The following is a brief overview of the content and structure of the model.

The main emphasis is on estimates of future requirements for university graduates by degree level and by academic field of study. The following steps are involved:

- prepare estimates of occupational stocks for some 52 HQM occupations. In general, these estimates are calculated using occupation/employment coefficients by industry based on 1971 Census data and applying these coefficients to industry employment projections to 1985. With respect to engineering occupations, the stock data are based on adjusted 1971 Census data. (See Appendix B for an elaboration of the data sources, concepts and definitions encountered in the use of published information on engineers);

- in the case of health and education occupations, the occupational stocks are based on administrative data collected by Health and Welfare and Statistics Canada. For selected occupations, largely in the engineering and technical fields, the occupation/employment coefficients are projected to rise to 1985;

- annual attrition estimates are calculated for each occupation starting with the 1971 sex and single year of age distributions obtained from the Census and applying death and retirement rates and estimates of emigrants from the occupation. The annual replacement demand is added to the change in the stocks to obtain an

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[1] MOSST, "MOSST HQM Demand Model - Methodology". This Technical Paper may be obtained upon request from the Communications Services Division, Ministry of State for Science and Technology.

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estimate of the number of new entrants required in the occupation each year. The new entrant estimates are adjusted, where appropriate, for the number of persons likely to be required with or without a university degree;

- the number of graduates required by occupation is multiplied by an educational field of study distribution which shows the educational background of entrants to the occupation. The matrix contains 70 fields of study for some 52 occupations for three degree levels (first professional or bachelor, masters, and PhD). The data are obtained from the 1973 Highly Qualified Manpower Post-Censal Survey (HQMPS) and pertain to the Census occupations in 1971 for persons under age 35. The field of study demand estimates are calculated by summing each of the 70 fields of study across all occupations for the three degree levels; and

- computation by a similar approach as the above of a detailed allocation and attrition sub-system for the occupation "university teacher", providing detailed estimates for some 71 teaching specialities at universities. This sub-model draws on detailed age and sex data contained in the Statistics Canada full-time university teacher file.

In summary, the approach used in the model provides:

- occupational forecasts which take account of technological change and inter-industry shift effects, and based on demographic and behavioural trends in health, law and education;

- a detailed attrition sub-system to calculate replacement demand by occupation based on death and retirement rates and emigration assumptions;

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- up-grading in educational requirements by occupation; and

- estimates of the educational requirements of new entrants into the various HQM occupations by the use of an occupation/education matrix.